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The Effect of Biofertiliser of Arbuscular Mycorrhizal Fungi (*Glomus intraradices*) on Wheat Plants Growth G168 and Sakha61

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الملخص.
يعتبر نبات القمح من المحاصيل ذات الأهمية الكبيرة لغذاء الإنسان. إن سوء استعمال الأسمدة الكيماوية غير آمن على صحة الإنسان كما أنها مرتفعة التكاليف، لهذا فمن الضروري إيجاد بدائل أخري للتسميد أكثر أماناً فطر الميكورهيزا *Glomus intraradices* يتميز بأنه يمد غزله ويتغلغل في المسافات البينية بين خلايا الجذور في منطقة القشرة مما يساعد على زيادة مساحات أسطح الامتصاص. أستخدم صنفين من أصناف القمح (.*Triticum aestivum* L) هما جي 168 وسخا 61 حيث ثم تنمية النباتات لمدة تسعين يوم بعد الإنبات بحيث تكون إما ملقحة بالفطر *G. intraradices* الميكورهيزا (معاملة) أو غير ملقحة بالفطر (غير معاملة). تم قياس ستة صفات مختلفة للإنتاج واستخدمت هذه الصفات كأدلة على نمو نباتات القمح وإنتاجيتها. ولها تأثير إيجابي على إنتاجِ الكتلة العضويةِ في النباتاتِ. أظهرت النتائج زيادة بنسبة متفاوتة لنمو النبات فى النباتات الملقحة بفطر الميكورهيزا مقارنة بغير الملقحة في كلا الصنفين وكانت النتائج بالنسبة لصنفين جي 168 و ساخا61 زيادة طول النبات إلى 45.55% و26.41 % عدد الأوراق كانت 111.7% و 27.27%, عدد أشطاء النبات كانت 50% و 25% الوزن الغض للمجموع الخضري كان 85.88% و 77.46%, وزن أحدث ورقة (ورقة العلم) كانت 150% و .81% على التوالي. بينما الطول الكلى للجذور كانت مماثلة تقريبا 51.22% و 49.29% للصنفين على التوالي .

الكلمات المفتاحية: فطر الميكورهيزا ، *Glomus intraradices*، نمو نبات القمح.

ABSTRACT

Wheat is one of the most important crops for food consumption. Misuse of chemicals fertilization is not safe for human health as well as it is expensive. It is important to find the alternatives. *Glomus intraradices* were used which is characterized by the formation of arbuscules as biofertilizers. Two wheat (*Triticum aestivum L.*) cultivars were nominated (G168 and Sakha61) they were grown up to ninety days after germination as *G. intraradices* treated and none treated (control). Six different yield related traits were measured. A positive effect of *G. intraradices* fungi on biomass production which depends on the specific plant G. intraradices fungus interaction. Yield related traits increased with different proportions as response for wheat roots inoculation with *G. intraradices* as compared with non-inoculated plants of the two cultivars. The results showed that the increases of two cultivars G168 and Sakha61 plant height were 45.55% and 26.41%, number of leaves were 111.7% and 27.27%, number of tillers plant were 50% and 25%, shoot fresh weight by 85.88% and 77.46%, weight of youngest elongate blade leaf increased by 150% and 81.81%, respectively. On the other hand, the percentage of increase was almost similar in root length 51.22% and 49.29% in both cultivars.

Keywords: *Arbuscular Mycorrhizal Fungi, Glomus intraradices,* Wheat Plants Growth.

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1. Introduction

Wheat is one of the most important cereal crops for food consumption. It has a wide cultivation range. Biofertilizers such as endo or ectomycorrhizal are greatly recommended to have a green product. The arbuscular mycorrhiza changes whatever source of phosphorus into phosphoric acid which acidifies the rhizosphere and thus increases the availability of elements for plants uptake. The increase of the availability of elements specially, calcium which plays the main role in cell signaling which could leads to change in part of the plant cell finally affect the plant growth [10]. This investigation aimed to study the effects of wheat root inoculation with mycorrhiza on plant growth and to screen some of the changes in wheat as response for this root inoculation with mycorrhizal, in the inoculated wheat cells and to compare it with the non-inoculated plants.

1.1. Objectives: To study the effect of wheat root inoculation with *Glomus intraradices* on the plant growth as detected using different yield related traits.

1.2. Literature Review

Mycorrhizal and plant growth:

Mycorrhiza developed a kind of symbiotic association with plants. These developed a kind of associations are assumed to play an important role in the land colonization by plants due to the ability of the symbiotic organisms in acquiring nutrients unavailable to non-mycorrhizal individuals [18,21,23] reported that AM fungi belong to the recently separated fungal phylum Glomeromycota. [16] reported that plant inoculation with mycorrhiza increased its adaptation to limited phosphorus (Pi) availability and increasing plant growth under low Pi conditions.

reported that [2, 8, 9] mycorrhizal colonization was higher in well-watered plants colonized with AM fungi isolates than water-stressed plants. The recorded improved growth, nutrient uptake and productivity of wheat plants demonstrate the potential of mycorrhizal inoculation in reducing the adverse effects of drought stress on wheat plants grown in semiarid areas of the world.

[22] reported that the inoculation with mycorrhiza increased all plant growth variables such as number of leaves, stem fresh weight, stem dry weight and root dry weight. [1, 3, 12, 14] used mycorrhizal and non-mycorrhizal wheat plants (*Triticum aestivum* L. cv. Sakha 93) higher uptake of nutrients (N, P, K, Mg and Ca) in the shoots and grains of wheat plants was obtained as a result of mycorrhizal inoculation regardless of the plant growth stage at which the drought stress was applied by mycorrhizal plants under well-watered conditions were higher than non-mycorrhizal ones by 60% and by 57, 67 and 65% when plants subjected water stress treatment at tillering, heading and grain-filling stages respectively. Wheat plants showed 118% dependency on the mycorrhizal fungi for its biomass production under well-watered conditions. However, the mycorrhizal dependency was 134, 133 and 124% when the stress treatment was applied at tillering, heading and grain-filling stages, respectively. The recorded improved growth, nutrient uptake and productivity of wheat plants demonstrate the potential of

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mycorrhizal inoculation in reducing the adverse effects of drought stress on wheat plants grown in semiarid areas of the world.

Reported that [4, 20] exploitation of arbuscular mycorrhizal fungi may be an important approach for development of reduced-input agriculture. They discuss the use of linear models to analyze variation in mycorrhiza response among diverse plant varieties in order to assess the value of mycorrhizas. Their approach allows elimination of variation linked to differences in plant performance in the absence of mycorrhizas and the selection of plant lines that might harbor of use to improve the mycorrhizal symbiosis in agriculture.

They illustrate their approach by applying it to previously publish and to novel data. They suggested that in dealing with a relative trait such as mycorrhiza effect, the choice of measure used to quantify the trait greatly affects interpretation. In the plant populations under consideration, they found evidence for a greater potential to increase mycorrhiza benefit than previously suggested.

2. Materials and Methods

2.1. Sandy culture experiment

A greenhouse trial with four replications was conducted two wheat cultivars (*Triticum aestivum* L.) nominated (G168 and Sakha61) which were obtained from the Agriculture Research Center. The plants were grown up to ninety days after germination as G. intraradices treated and none treated ones (control).

2.2. Mycorrhiza treatment:

Wheat plants of the two aforementioned cultivars were grown in pots with thirty cm diameter, each pot was filled with water well washed sand (7-9 kg / pot) mixed with equal amounts of *G. intraradices* inoculants for the treated plants. The arbuscular mycorrhiza inoculants were obtained from biofertilizers unit, faculty of agriculture, Ain Shams University. Four pot for each of the two cultivars under investigation. On the other hand, another four pots for each of the two cultivars were filled with similar amounts of water well washed sand (7-9 kg / pot) for control plants. Four seedlings were grown in each pot. The experiment was terminated after ninety days of germination.

The effect of wheat roots inoculation with G. intraradices on the plant growth was detected using six different yield related traits which were measured in the end of the experiment. The traits were plant height, number of leaves, number of tillers, shoot fresh weight, weight of the youngest elongate blade leaf, and total root length. The weights were measured using two decimal, sensitive balances.

2.3. Statistical Analysis:

The tests were performed for six traits: plant height, Plant leaves number, plant tillers number, shoot fresh weight, weight of YEB leaf and total root length for the two types of wheat G168 and Sakha61.

Due to small sample size and no prior knowledge of the parent population distribution we used non-parametric test for significance namely the Wilcoxon test. Data from statistically analyzed using SPSS version 15.

3. Results and Discussions

3.1. Effect Mycorrhizal on Plant Growth:

The arbuscular mycorrhiza causes changes in plant growth and productivity [6]. The growth of two cultivars under investigation G168 and Sakha61 were evaluated as

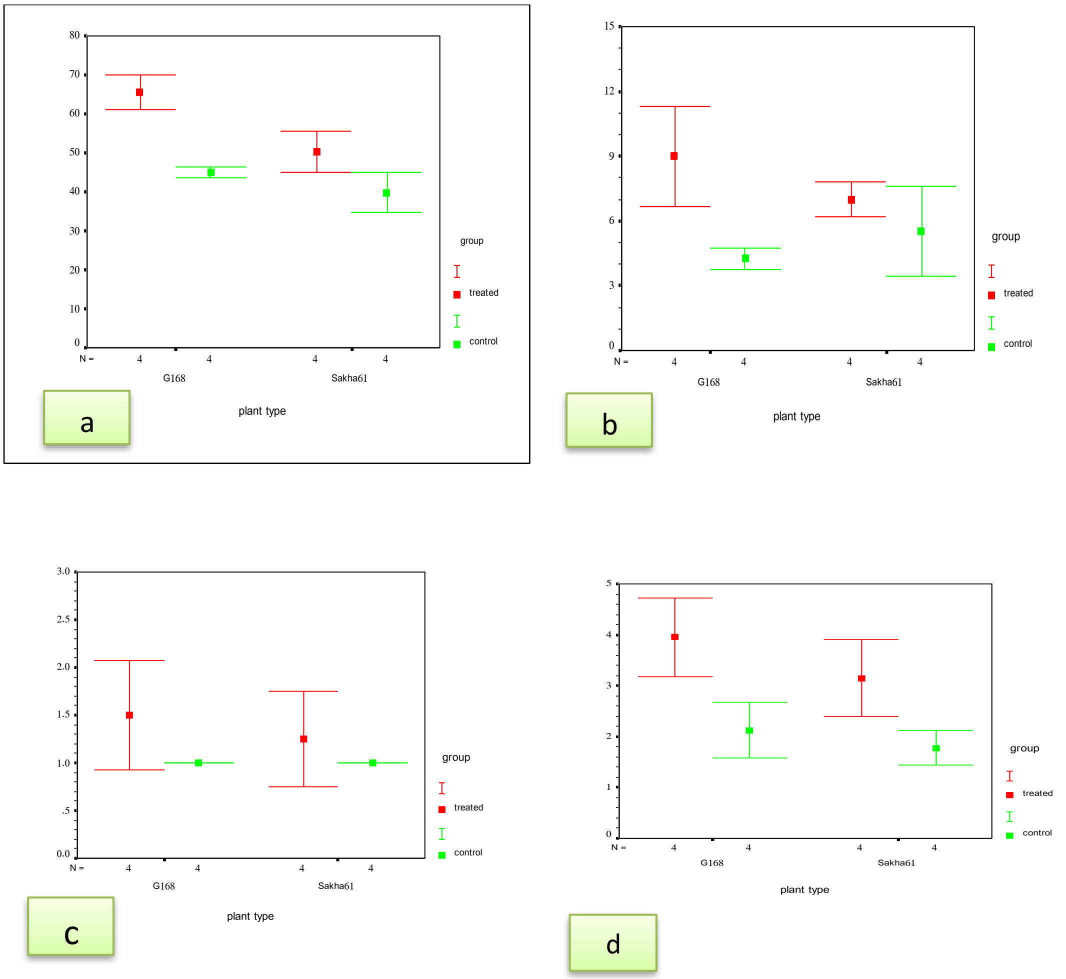
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response for *G. intraradices* inoculation and control (non-inoculated plants) in four replications. The evaluation was performed in sand culture experiment under greenhouse conditions on the base of the following yield related traits which were scored and used as detectors for the changes in plant growth as response for arbuscular mycorrhizal inoculation, plant height, number of leaves, number of tillers, shoot fresh weight, weight of the youngest elongate blade leaf and total root length.

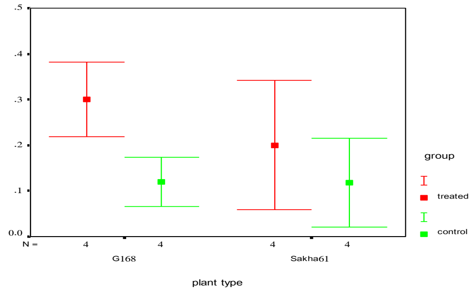
In general plant growth of the two cultivars under investigation was elevated as response for root inoculation with *G. intraradices*, as detected from the aforementioned yield related traits.

3.2. Yield related traits:

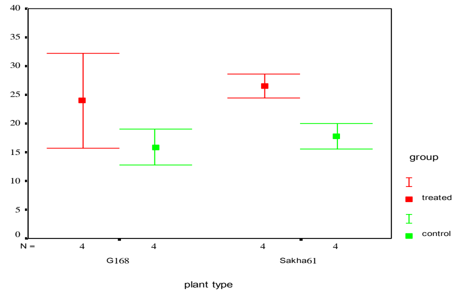
plant types control, treatment, minimum and maximum and mean Yield related traits, standard deviation was significantly different of two wheat cultivars G168 and Sakha61 under *G. intraradices* inoculation as compared with non- inoculated plants (Fig1. a, b, c, d, e, f).



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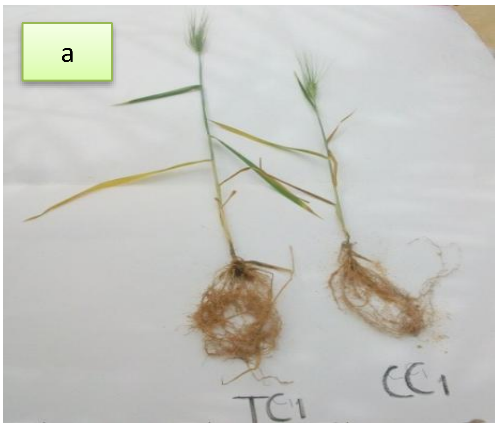


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Figure 1. Effect of *Glomus intraradices* on a. plant height, b. plant leaves number, c. tillers number plant, d. shoot fresh weight, e. weight youngest elongate blade leaf, f. root length of two wheat cultivars, data are presented as mean ± standard deviation.

3.2.1. Plant Height:

The average was increased from 45 cm in non-inoculated plants to 65.5 cm in the G. intraradices inoculated plants in cultivar G168 with increasing percentage of 45.55% of the control ones significant. On the other hand, the trait was increased from 39.75cm in non-inoculated plants to 50.25cm in the G. intraradices inoculated plants in cultivar Sakha61 with increasing percentage of 26.41% of the control ones significant. These results indicated that G168 plants had a greater response for *G. intraradices* inoculation than Sakha61 in this trait. Plant height was significantly affected under G. intraradices (fig2.a, b.), [5, 24] reported that colonization by *G. clarum* and *G. deceptions* increased plant height and diameter. Survival rates were higher in the AM-colonized seedlings at 180 days after transplantation than in the control seedlings. The results suggest that AM fungi can accelerate the establishment of the planting stocks of Dyera polyphylla and Aquilaria filaria.



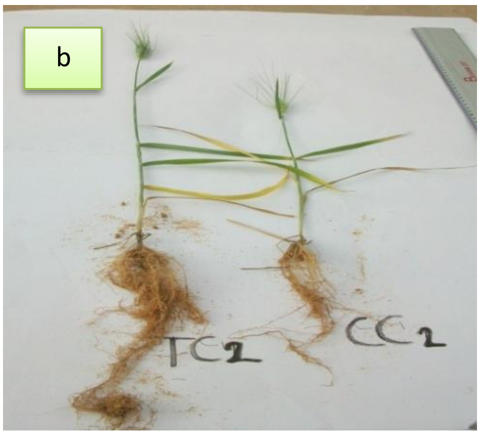


Figure 2. Effect of Glomus intraradices and control on plant height of two wheat cultivars, a. G168, b.Sakha61.

3.2.2. Plant Leaves Number:

Showed that the average of plant leaves number was increased from 4.25 in non-inoculated plants to 9.00 leaves plant in the

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G. intraradices inoculated plants in cultivar G168 with increasing percentage of 111.7% of the control ones significant. On the other hand, the trait was increased from 5.50 in non-inoculated plants to 7.00 leaves plant in the *G. intraradices* inoculated plants in cultivar Sakha61 with increasing percentage of 27.27% of the control ones but not significant. These results indicated that G168 plants had a greater response was significantly than Sakha61 in this trait (fig3. a, b.), [11] reported that effects of mycorrhizal infection by *Glomus etunicatum* Becker & Gerd. And P amendment (three levels) on growth and reproduction of *Ahutilon theophrasti* Medic. Mycorrhizal infection increased total leaf area, but individual leaf size was more affected than leaf number.



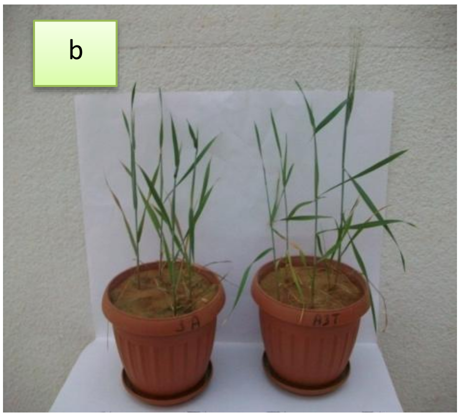


Figure 3. Effect of *Glomus intraradices* and control of two wheat cultivars, a. G168, b.Sakha61.

3.2.3. Plant Tillers Number:

Increased from 1.0 in non-inoculated plants to 1.5 in the G. intraradices inoculated plants in cultivar G168 with increasing percentage of 50% of the control ones but not significant. On the other hand, the trait was increased from 1.0 in non-inoculated plants to 1.25 in the *G. intraradices* inoculated plants in cultivar Sakha61 with increasing percentage of 25% of the control ones too not significant. These results indicated that G168, Sakha61 plants the same response for G. intraradices inoculation in this trait. This trait is highly correlated with the grain yield where the increasing of plant tillers number if not presented significant in increasing in the grain yield plant. reported that [13] G. intraradices increased the dry weight and the height of the plants but not the tiller number.

3.2.4. Shoot Fresh Weight:

Increased from 2.125gm in non-inoculated plants to 3.95gm in the G. intraradices inoculated plants in cultivar G168 with increasing percentage of 85.88% of the control ones significant. On the other hand, the trait was increased from 1.775 in non-inoculated plants to 3.15gm in the G. intraradices inoculated plants in cultivar Sakha61 with increasing percentage of 77.46% of the control ones significant. These results indicated that G168 plants had a greater response for G. intraradices inoculation than Sakha61 in this trait. This trait is highly correlated with total biomass which usually used to express the vegetative growth in plants. [24] reported that increased shoot. Shoot N and P concentrations of the seedlings were increased by AM colonization by as much as 70-153% and 135-360%, respectively. Rates were higher

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in the AM-colonized seedlings transplantation than in the control seedlings. The results suggest that AM fungi can accelerate the establishment of the planting stocks.

3.2.5. Weight of the youngest elongate blade leaf:

The results showed that the average weight of youngest elongate blade leaf was increased from 0.12gm in non-inoculated plants to 0.3gm in the G. intraradices inoculated plants in cultivar G168 with increasing percentage of 150% of the control plant significant. On the other hand, the trait was increased from 0.1175gm in non-inoculated plants to 0.2gm in the G. intraradices inoculated plants in cultivar Sakha61 with increasing percentage of 81.81% of the control ones not significant. These results indicated that both cultivars G168 and Sakha61 plants have different responses for *G. intraradices* inoculation.

3.2.6. Total Root Length:

Showed that the average of root length was increased from 15.875cm in non-inoculated plants to 24cm in the G. intraradices inoculated plants in cultivar G168 with increasing percentage of 51.22% of the control ones not significant. On the other hand, the trait was increased from 17.75cm in non-inoculated plants to 26.5cm in the G. intraradices inoculated plants in cultivar sakha61 with increasing percentage of 49.29% of the control ones significant. [15,17] reported that AMF by increasing the absorption of water and nutrients for plants, competition with pathogens for the space and nutrients, increasing the level of selective absorption and permeability of roots, and lignification of the root cell wall increases the resistance of symbiotic plants against pathogens and their growth and yield.

3.3. Testing the effect of treatment:

The results are summarized in the following tables. We use 5% level of significance. Showed differences in growth rate percent after 90 days growth among used six different yield related traits. Growth rate of the studied wheat root inoculation with G. intraradices different yield related traits were affected by the present sum of rank 26.00 in treated compared 10.00 to control in all plant height, leaves number, shoot fresh weight, and the weight of youngest elongate blade leaf (YEB), the values of G168 gave the significant growth rate (p=.0145). However, in Sakha61 were plant height, shoot fresh weight, total root length the same values significant. Deficiency sum of rank 22.00 in treated compared 14.00 to control in tillers number, total root length the growth rate of G168 showed the not significant growth rate (p=.1715) However, in Sakha61 were leaves number, tillers number and the weight of youngest elongate blade leaf (YEB) the same values. Generally, it possible to conclude that, wheat root inoculation with G. intraradices resulted in increasing of plant growth in form of the increase in plant height, number of leaves, and number of tillers, shoot fresh weight, the weight of youngest elongate blade leaf and root length with different proportions. Although the inoculation with *G. intraradices* resulted in increasing in all of the investigated traits, the response was varied from trait to another. Moreover, the response was significantly different of two wheat cultivars G168 and Sakha61 under *G. intraradices* inoculation as compared with non-inoculated plants. The results were in greens with the finding of [2,

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6, 19, 25] When the results of the study were evaluated, all traits were significantly affected by AMF application in dry conditions. The highest values of plant height, root length, shoot and root dry weight were obtained by application. Shoot fresh weight, the highest values under control conditions with the highest water. Root fresh weight and leaf area also increased with increasing water dose, and application of AMF to both seed and root gave the best results.

In the last row of the second and forth tables the result “Significant” indicates that treated wheat group gave larger trait values for the trait than the control group while the result “non-significant” indicates that the data did not provide enough evidence to conclude that there is significant difference in the values of the trait between the treated and the controlled groups of wheat.

3.3.1. Testing the significance of treatment on G168:

Data presented in (Table1, 2) showed differences in growth rate percent after 90 days growth among used six different yield related traits. Growth rate of the studied wheat different yield related traits were affected by the present sum of rank 26.00 in treated compared 10.00 to control in all plant height, leaves number, shoot fresh weight, and the weight of youngest elongate blade leaf (YEB), the values of G168 gave the significant growth rate (p=.0145). However, tillers number, total root length. deficiency sum of rank 22.00, 25.00 in treated compared 14.00, 12.50 to control the growth rate of G168 showed the not significant growth rate (p=.1715, p=.057) respectively.

Table (1): Arrangement of the six different yield related traits in the cultivar G168 as treated and control.

yield-related traits	group	N	Mean Rank	Sum of Ranks
Plant Heights (cm)	treated	4	6.50	26.00
	control	4	2.50	10.00
	Total	8		
Plant Leaves Number	treated	4	6.50	26.00
	control	4	2.50	10.00
	Total	8		
Plant Tillers Number	treated	4	5.50	22.00
	control	4	3.50	14.00
	Total	8		
Shoot Fresh Weight (gm)	treated	4	6.50	26.00
	control	4	2.50	10.00
	Total	8		
Weight of YEB Leaf (gm)	treated	4	6.38	25.50
	control	4	2.63	10.50
	Total	8		
Total Root Length (cm)	treated	4	5.88	23.50
	control	4	3.13	12.50
	Total	8		

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Table (2): Test Statistics Grouping Variable of Significance at 5% for six different yield-related traits in the cultivar G168, where (a) is the mean, not corrected for ties.

	Plant Heights (cm)	Plant Leaves Number	Plant Tillers Number	Shoot Fresh Weight (gm)	Weight of YEB Leaf (gm)	Total Root Length (cm)
Mann-Whitney U	.000	.000	4.000	.000	.500	2.500
Wilcoxon W	10.000	10.000	14.000	10.000	10.500	12.500
Z	-2.323	-2.397	-1.528	-2.366	-2.205	-1.597
Asymp. Sig. (2-tailed)	.020	.017	.127	.018	.027	.110
Exact Sig. [2*(1-tailed Sig.)]	.029(a)	.029(a)	.343(a)	.029(a)	.029(a)	.114(a)
1-tailed Significance	.0145(a)	.0145(a)	.1715(a)	.0145(a)	.0145(a)	.057(a)
Significance at 5%	Significant	Significant	Not Significant	Significant	Significant	Not Significant

3.3.2. Testing the significance of treatment on Sakha61:

Data presented in (Table3, 4) showed differences in growth rate percent after 90 days growth among used six different yield related traits. Growth rate of the studied wheat different yield related traits were affected by the present sum of rank 26.00 in treated compared 10.00 to control in all plant height, shoot fresh weight, total root length the values of Sakha61 gave the significant growth rate (p=.0145). However, leaves number, tillers number and the weight of youngest elongate blade leaf (YEB). deficiency sum of rank 22.00, 20.00, 21.00 in treated compared 14.00, 16.00, 15.00 to control the growth rate of Sakha61 showed the not significant growth rate (p=.1715, p=.343, p=.243) respectively.

[6,7], which could be related to the effect of wheat root inoculation with mycorrhiza on plant growth and productivity.

Table (3): Arrangement of the six different yield related traits in the cultivar Sakha61 as treated and control.

yield related traits	group	N	Mean Rank	Sum of Ranks
Plant Heights (cm)	treted	4	6.25	25.00
	control	4	2.75	11.00
	Total	8		
Plant Leaves Number	treted	4	5.50	22.00
	control	4	3.50	14.00
	Total	8		
Plant Tillers Number	treted	4	5.00	20.00
	control	4	4.00	16.00
	Total	8		
Shoot Fresh Weight (gm)	treted	4	6.50	26.00
	control	4	2.50	10.00
	Total	8		
Weight of YEB Leaf (gm)	treted	4	5.25	21.00
	control	4	3.75	15.00
	Total	8		
Total Root Length (cm)	treted	4	6.50	26.00
	control	4	2.50	10.00
	Total	8		

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Table (4): Test Statistics Grouping Variable of Significance at 5% the six different yield related traits in the cultivar Sakha61, where (a) is the mean, not corrected for ties.

	Plant Leaves Number	Plant Tillers Number	Shoot Fresh Weight (gm)	Weight of YEB Leaf (gm)	Total Root Length (cm)	Plant Heights (cm)
Mann-Whitney U	1.000	4.000	6.000	.000	5.000	.000
Wilcoxon W	11.000	14.000	16.000	10.000	15.000	10.000
Z	-2.021	-1.176	-1.000	-2.337	-.893	-2.323
Asymp. Sig. (2-tailed)	.043	.240	.317	.019	.372	.020
Exact Sig. [2*(1-tailed Sig.)]	.057[a]	.343[a]	.686[a]	.029[a]	.486[a]	.029[a]
1-tailed Significance	.0285[a]	.1715[a]	.343[a]	.0145[a]	.243[a]	.0145[a]
Significance at 5%	Significant	Not Significant	Not Significant	Significant	Not Significant	Significant

4. Conclusion

The results showed that all the investigated yield related traits increased with different proportions as response for wheat roots inoculation with *G. intraradices* as compared with non-inoculated plants of the two cultivars. These results highlight the positive role of G. intraradices as an effective biofertilizer that can reduce dependence on chemical fertilizers, improve plant productivity, and promote sustainable agricultural practices.

5. Recommendations

1- Extensive studies on the wheat plant that would lead to increase yield and improve the specification of production and increase the capacity to carry bio-environmental stress such as plant diseases and non-bio such as salinity and drought.

2- Find alternatives to fertilize the chemical, such as biological fertilization of certain types of fungi, including mycorrhizal and other organisms that are used as fertilizer is vital to the plant through the living symbiotic with him to increase production to meet the large food gap between production and consumption.

3- Further studies to better understand the nature of the symbiotic relationship between host plant and organism used as fertilizer in order to maximize access to the benefit of bio-fertilizer and repercussions on the production plant.

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